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ENDEAVOUR HYDROTHERMAL VENTS MARINE PROTECTED AREA MONITORING INDICATORS, PROTOCOLS AND STRATEGIES

Endeavour Hydrothermal Vents. Photo by Verena Tunnicliffe and S. Kim Juniper

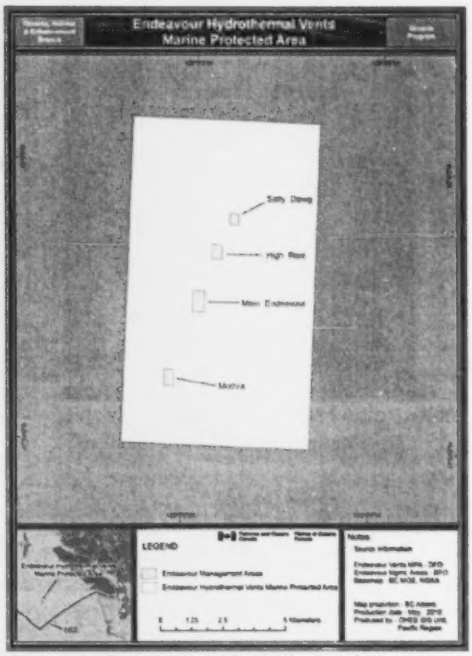

Figure 1: Endeavour Hydrothermal Vents Marine Protected Area

Context:

In support of the Health of the Oceans Initiative, Fisheries and Oceans Canada (DFO) Science provides advice on the ecosystem indicators, monitoring protocols and the strategies necessary to evaluate whether the conservation objectives for Marine Protected Areas (MPAs) are being met. The Endeavour Hydrothermal Vents Marine Protected Area (EHV MPA) was designated under the Oceans Act in March 2003.

The indicators, protocols and strategies identified are not intended to address non-biological (e.g. social or economic) objectives or evaluate compliance with regulations, licenses or other management measures.

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SUMMARY

- The identification of appropriate indicators, monitoring protocols and strategies to assess whether a Marine Protected Area (MPA) is achieving the established conservation and management objectives is a key component of overall MPA management planning and implementation.
- This assessment proposes a five-step framework based on the Pathways of Effects (PoE) and Ecological Risk Assessment (ERA) methods, for the identification of indicators to monitor the achievement of ecosystem objectives established for any MPA.
- Measurable conservation objectives are required before potential indicators and protocols can be proposed for Endeavour Hydrothermal Vents Marine Protected Area (EHV MPA). Further work to develop these is recommended.
- A preliminary Pathways of Effects (PoE) analysis was conducted for human activities currently occurring at EHV MPA. Further work is necessary to finalize these PoE assessments.
- To support the identification of indicators, collection of baseline data to complete an Ecological Risk Assessment of the stressors identified for the EHV MPA and a comprehensive reporting system for existing and proposed activities is recommended.

INTRODUCTION

Rationale for Assessment

Marine Protected Areas (MPAs) are designated by DFO under Canada's *Oceans Act* to conserve biodiversity and ecosystem function of a specific habitat or habitats. Once designated, the conservation objectives for an MPA define the components of the ecosystem that are vulnerable to human activities and that will require monitoring.

Supported by the *Health of the Oceans Initiative*, DFO Science has been asked to provide the following advice respecting the Endeavour Hydrothermal Vents Marine Protected Area (EHV MPA):

- Identify human induced threats and associated impacts that have the potential to compromise the achievement of the conservation objectives.
- Evaluate the completeness and appropriateness of the pathway of effects assessments for the MPA.
- Determine whether the potential impacts identified for each threat are adequately covered and whether the assumptions are appropriate and clearly identified.
- Develop recommendations for indicators, monitoring protocols and strategies that are appropriate to evaluate and monitor the achievement of the conservation objectives, the effects of the identified threats, and any actions undertaken to mitigate or eliminate threats.
- Where appropriate, identify any outstanding information gaps and potential approaches to address the gaps.

The indicators herein are not intended to address non-biological or ecological (e.g. social, economic or historical) aspects of monitoring, with the exception of threats as presented by human activities.

Background

To establish meaningful indicators and monitoring protocols, it is imperative that the conservation objectives are measurable, relevant to current policies, and sensitive to meaningful thresholds (Failing and Gregory 2003). Conservation objectives that include targets, time frames and desired probabilities for achieving the targets are desirable to provide variables on which to base meaningful indicators and monitoring protocols.

Where there is an absence of specific objectives, monitoring efforts to evaluate the extent and nature of the effects of human activities can be developed. This work will allow for an evaluation of risk and prioritization of future monitoring and management measures.

This assessment represents the first step in the development of indicators and monitoring protocols for the EHV MPA. The focus of this assessment was to:

- Conduct a preliminary Pathways of Effects (PoE) evaluation on the human activities that have the potential to stress the ecosystem and identify their likely effects;
- Develop a framework that will lead to indicator selection in order to monitor the effect of human activities that have the potential to stress the ecosystem for any MPA; and
- Describe current activity-based monitoring programs and gaps in the existing programs that are necessary to support the long-term development of a monitoring plan for the EVH MPA.

Description of the Marine Protected Area

The EHV MPA is found approximately 250 km southwest of Vancouver Island (Figure 1), and is part of a larger network of vents and submarine volcanoes known as the Juan de Fuca Ridge located off the west coast of North America. Here the tectonic plates diverge and new oceanic crust is extruded. The vents (~2200 metres deep) are formed as cold sea water seeps down through the crust where it is heated by the underlying molten lava and ejected into the water column. This rich ecosystem is supported by microbes whose life processes are fuelled by the chemical energy from the emerging fluids in the hydrothermal vents. The vent fields support a high level of species richness compared to the nearby ocean floor, including many species that are rare or endemic. At the time of designation, twelve of the sixty species known to occur at the Endeavour hydrothermal vents were considered endemic to the area (Tunnicliffe and Thomson 1999).

Conservation Objective

The Management Plan (DFO 2010a) for the EHV MPA states the following conservation objective:

> *Ensure that human activities contribute to the conservation, protection and understanding of the natural diversity, productivity and dynamism of the ecosystem and are managed appropriately such that the impacts remain less significant than natural perturbations (e.g. magmatic, volcanic or seismic).*

The conservation objective for EVH MPA needs further refinement to address the scale of impact from human activities and the uncertainty regarding the scale of natural variation. Measurable objectives can be derived from the refinement of this conservation objective.

Management of the Marine Protected Area

The management plan for EHV (DFO 2010a) uses the following management objectives to support decisions regarding human activities within the MPA:

1. *Coordinate human activities to ensure responsible procedures are followed (e.g. sampling, instrument deployment and retrieval, data sharing, appropriate debris disposal).*
2. *Contribute to public awareness of the values of marine ecosystems and the need to protect them.*

The management plan for EHV MPA also elaborates on the regulations to achieve the conservation objective for the MPA. The Management Plan addresses matters such as monitoring, enforcement and compliance; and provides the details required to ensure that the rationale for management decisions, prohibitions, controls and approvals is clearly understood. As stated by the Regulations, activities in the MPA are managed through (1) specific exceptions to the general prohibitions according to specified conditions; and (2) the submission and approval of plans for specified activities according to specified conditions.

Regulations for the Marine Protected Area

The regulations form the basis of the management of the MPA and state that '*no person shall disturb, damage or destroy, or remove… any part of the seabed, including a venting structure, or any part of the subsoil, or any living marine organism or any part of its habitat; or carry out any underwater activity… that is likely to result in the disturbance, damage, destruction or removal of any part of the seabed, including a venting structure, or any part of the subsoil, or any living marine organism or any part of its habitat*' with the following exceptions.

- Activities for the purpose of public safety, law enforcement, Canadian sovereignty or national security, as well as activities undertaken on behalf of the Canadian Forces are allowed.
- Scientific research for the conservation, protection and understanding of the area may be approved throughout the MPA under specific conditions.
- Fishing by Aboriginal Peoples in accordance with the *Aboriginal Communal Fishing Licenses Regulations* is permitted.
- Commercial fishing within the MPA may be allowed as long as this is carried out in accordance with subsection 7(1) of the *Fisheries Act*.
- Vessel travel is permitted pursuant to the *Canada Shipping Act, 2001* and foreign vessel travel pursuant to the *Canada Shipping Act, 2001* and the *Coasting Trade Act*.

ASSESSMENT

Indicator Identification Framework

The framework developed for the stressor-based identification of indicators to monitor the achievement of the conservation objective includes the following steps, which are further outlined below:

1. Use the pathways of effects (PoE) approach to identify the stressors that result from each activity and their potential effect on the ecosystem.

2. Conduct a risk assessment using an Ecological Risk Analysis Framework (ERAF) on the effects that have been identified though the PoE evaluation.
3. Refine conservation objectives in measurable terms.
4. Identify candidate indicators and protocols to monitor the effect of stressors from activities that have been assessed or prioritized through the Ecological Risk Analysis Framework that warrant monitoring (i.e. sufficient risk to achievement of the conservation objectives).
5. Identify candidate indicators and protocols to monitor the ecosystem reference state to serve as baselines for comparison to indicators relevant to stressors.

Pathway of Effects Assessment

Pathways of Effects models or diagrams describe the type of cause-effect relationships that are known to exist, and the mechanism by which stressors ultimately lead to effects in the aquatic environment. For each human activity there are known stressors to the environment. The PoE outlines the mechanisms by which human activities may stress the environment and the resulting effects on the ecosystem state. This relationship can be described in the following schematic:

Activity → Stressor → Effect

For each cause-and-effect relationship, a pathway is created by connecting the attributes of the stressor to some ultimate effect on the ecosystem (Boutillier et al. 2010).

Ecological Risk Assessment

An ecological risk assessment is conducted to understand the nature and extent of the effects caused by stressors from a specific activity. Risk to the ecosystem is determined by examining the scale and intensity of negative effects, the sensitivity of species and habitats, and the likelihood of the effect to occur. The level of risk associated with a particular activity can then be ranked according to the expected severity of impact and the probability that an activity will occur. Ranking may be completed using either indices or probabilities. Many different types of ecological risk assessment frameworks exist to address different ecosystems and human activities. DFO has developed an Ecological Risk Assessment Framework for habitat assessment that can be used to understand the impacts of activities within an MPA (DFO 2010b).

Development of Operational Objectives

If conservation objectives established for a particular MPA are not measurable, the identification of the stressors, their effects and the Ecological Risk Assessment Framework can inform the development of measurable conservation objectives. Conservation objectives thus redefined are often referred to as operational objectives.

Identification of Candidate Indicators

Indicators are used to measure the achievement of a conservation objective, and if used in a structured decision support context, their selection must be guided by suitable criteria (Rice and Rochet 2005). These criteria will assess the quality of the information provided by a candidate indicator. It is essential that the indicators selected describe a property of the ecosystem that can be measured (either directly or indirectly). The candidate indicators should also be sensitive, responsive to change and have specificity to a particular management action. Other

criteria to consider in the screening process include the existence of historical data, public awareness, and theoretical basis for use of the particular indicator. Cost is also a consideration when determining whether a specific indicator can be monitored.

Indicators used to support decision making should answer two basic questions: (1) Is the conservation objective being met, and (2) is MPA management consistent with current DFO policies and legislation? These two questions should be expanded to a set of scientifically based questions and testable hypotheses that relate to the specific operational objectives for the MPA, and to the human activities that impact the MPA ecosystem. The questions should be limited to those that can provide managers with information needed for decision-making; otherwise the list of questions (and the indicators needed to answer them) will become long and unrealistic.

Once the key questions for management can be identified, then the selection of potential indicators can begin by examining the information needed to answer the key questions. It is important that indicators inform specific decisions regarding human activities, and provide information on the reference state of the ecosystem. Indicators and protocols to measure the achievement of the conservation objective can be grouped into one of two categories; those that monitor the impact of human activities and those that monitor a reference state.

Identification of Candidate Monitoring Protocols

Different types of monitoring are needed for a Marine Protected Area monitoring program: 1) Activity monitoring to determine the nature and extent of impact from human activities in the area; 2) Compliance monitoring to ensure that regulations and legislation around human activities are being followed; 3) Trend monitoring to track changes in the ecosystem through time; and 4), Effectiveness monitoring to evaluate ability of management actions to meet conservation objectives.

Identification of Potential Stressors for EHV

The following PoE assessment describes the impacts to the marine environment that are known to result from human activities that currently take place within or near the EHV MPA. These accounts are descriptions of the potential effects from each activity, not assessments of the actual impacts of these activities. The effects from stressors are assessed related to their potential impact on populations, communities and habitat. It is important to note that not all effects described below are negative, and that further assessments by experts may be necessary to characterize the level of risk to the marine environment from each of the activities described.

Vessel Traffic

There likely exists a small amount of vessel traffic in the area. However, due to the remote location of this MPA the amount of traffic is unknown. The potential pathways of effects from vessel traffic are outlined in Table 1.

Table 1. Pathways of Effects for Vessel Traffic

Activity	Stressor	Effect
Vessel Traffic	Vessel strikes	Removal of individuals (marine mammals)

Scientific Research and Monitoring

Scientific research is the only activity that currently takes place along the seafloor within the MPA boundary. Researchers are interested in the site for public awareness and education, to further the understanding of deep ocean community structure and function, and as a natural laboratory to study ore-deposition processes. All research in the area is conducted according to the regulations and the pathways of effects are described in Table 2. Depending on the type of research conducted, the activities may produce stressors similar to vessel traffic, which is described above.

Table 2. Pathways of Effects for scientific research and monitoring activities

Activity	Stressor	Effect
Scientific research & monitoring	Sample collection (water, sediment, biota)	Loss of biodiversity
		Changes in biogenic structure (complex habitat)
		Trophic effect from the reduction of populations (predator &/or prey) that cascade through the ecosystem
	Unintentional collisions	Loss of habitat
		Indirect effects on biodiversity from the destruction of habitat and biogenic species that create complex habitat
	Light	Harassment of species (benthic)
	Debris (garbage)	Alteration of habitat
	Aquatic Invasive Species (from equipment)	Reduced available habitat
		Loss of biodiversity
		Alteration of ecosystem function
	Sound energy introduction (noise)	Harassment of species (marine mammals)

Tourism

Although tourism interest at EHV MPA is extremely limited, tourism operators have expressed interest in conducting submarine tours to the area. Impacts from submarine activities would be similar to those from submersible research vehicles described for science research and monitoring, and to those described in vessel traffic above. Additional pathways of effects are described in Table 3.

Table 3. Pathways of Effects for tourism activities

Activity	Stressor	Effect
Tourism	Light	Harassment of species (benthic)
	Physical disturbance	Harassment of species (benthic)
		Alteration of habitat

Selection of Indicators for Endeavour Hydrothermal Vents Marine Protected Area

In order to select appropriate and meaningful indicators for EHV MPA, the conservation values and operational objectives should be refined to be measurable and describe conservation priorities. The management plan for EHV MPA was revised in 2010 (DFO 2010a); however, operational objectives that are measurable and describe conservation priorities still need to be developed.

Monitoring Protocols for Endeavour Hydrothermal Vents Marine Protected Area

The final selection of monitoring protocols cannot be completed until specific indicators are selected. However, in the interim, collection of information to inform the Ecological Risk Assessment Framework evaluation, support risk ranking, and conduct baseline monitoring will support the evaluation of the conservation objectives.

Strategies for Monitoring

DFO is responsible for the coordination of science monitoring in the MPA. However, a collaborative effort involving a variety of organizations and research groups will be necessary to successfully monitor this remote area. Furthermore, it is a key objective of the Canada Federal Marine Protected Areas Strategy to enhance collaboration for management and monitoring of marine protected areas (DFO 2005). Data gathered from vessels or aircraft of opportunity, fixed station monitoring, and remote sensing should be used whenever possible. Coordination of MPA monitoring with existing departmental monitoring strategies (i.e. fisheries management, marine mammal monitoring) is needed for efficient and cost-effective monitoring.

Regardless of the strategies used, planning for long-term monitoring activities is crucial for the development of a long-term data set and the ultimate success of a monitoring program. Although collaborations are critical for monitoring this MPA, a dedicated sampling program may be necessary to ensure all proposed monitoring activities are completed.

To determine the nature and effects that human activities have on the achievement of the broader conservation objective, a comprehensive reporting system is required that captures existing and proposed activities at EHV MPA. Currently, reporting of activities in the area takes place using cruise reports, log sheets and scientific licences.

Development of a data management system is an integral component to a monitoring program, as it will ensure data integrity and access. Data management will be necessary to compile historic information, for completing risk assessments, and for current and future monitoring activities.

Sources of Uncertainty

Several knowledge gaps exist that will require research or data collection in order to develop a monitoring program. There are information gaps regarding the frequency of human activities in the MPA, as well as uncertainties regarding the nature and extent of the stressors and their effects. The ability to complete the steps in the indicator identification framework will be dependent on the data available.

Knowledge gaps include a detailed understanding of the species composition, colonization, and succession processes of the vent ecosystem. The high density vent communities consist of many previously undescribed species and the impact of the plumes on the spatial distribution of organisms and trophic levels of the ecosystem are not well understood. More importantly, there is a limited understanding of the natural range of environmental variation and the recovery rate of the ecosystem after impact from human activities.

There are sources of uncertainty regarding the ecosystem structure and function that will continue to exist, regardless of how extensive and thorough a monitoring program becomes. Regime shifts due to large global processes such as the Pacific decadal oscillation (PDO), El Niño, and climate change may have unanticipated results on the MPA ecosystem. These large scale stressors or ecosystem drivers are not within the scope of management, but will need to be taken into consideration and may require indicators and monitoring. Cumulative impacts also need to be acknowledged when assessing whether the conservation objective(s) have been achieved, or when developing management measures.

CONCLUSIONS AND RECOMMENDATONS

The identification of meaningful indicators, monitoring protocols and strategies to assess whether an MPA is achieving the established conservation and management objectives is a key component of overall management planning and implementation. Further refinement of operational conservation objectives for EHV MPA is necessary for the identification of appropriate indicators and monitoring protocols.

A five-step stressor-based Indicator Identification Framework, based on the Pathways of Effects (PoE) and Ecological Risk Assessment methods, for the identification of indicators to monitor the achievement of ecosystem objectives established for any MPA was developed and endorsed. A preliminary PoE assessment was conducted for human activities currently occurring at EHV MPA to inform decisions about what data and sampling is necessary to complete the remaining steps in the framework. A more thorough evaluation of the stressors to this MPA needs to be completed before the risk assessment step can be undertaken. This evaluation, combined with measurable conservation objectives, will facilitate the identification of indicators, monitoring protocols and strategies for EHV MPA.

Recommendations and Next Steps:

1. Refine the conservation objective of the EHV MPA.
2. Collect and compile data to develop a knowledge base of rare and endemic species (or lowest possible taxon).
3. Implement a comprehensive reporting system for existing and proposed activities in SK-B MPA, to determine the nature and effect of human activities.
4. Utilize the stressor-based indicator identification framework to identify appropriate indicators for monitoring the achievement of the EHV MPA objectives.

SOURCES OF INFORMATION

This Science Advisory Report has resulted from a Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, Regional Advisory meeting of October 26 – 28, 2010 on Pacific Review of Bowie Marine Protected Area (MPA) monitoring protocols, Pacific Review of Endeavour Ridge Area monitoring protocols. Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

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